§2. Effect of Magnetic Shear on Electron Cyclotron Wave during Propagation in Plasmas

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Polarization of a wave propagating in plasma is affected by magnetic field. In case of parallel propagation, it is well known as Faraday effect. Also in case of perpendicular propagation, state of polarization as a composition of two orthogonal modes, X- and O- modes is affected by phase difference between the two modes and magnetic shear effect. Under the existence of magnetic shear in plasma with sufficient density, the two modes tend to keep their characteristic: the direction of electric field oscillation of X-mode wave tends to be perpendicular to the magnetic field direction and that of O-mode to be parallel. On the other hand, X- and O-mode components show mutual oscillatory interchange during propagation.

In CHS experiment with 100ms ECH pulses, evidence of the effect of magnetic shear is clearly obtained. Figure 1 shows a summary of the experiment. Tdelay is a delay time of plasma break down from start of ECH pulse. nl@riseup is line density just after plasma break down. nl@100ms is that near the end of ECH pulse. Magnetic axis is at 92.1cm and magnetic field there is 0.95T: magnetic field for 2nd harmonic heating by 53.2GHz wave. ECH beam is injected to vertically elongated plasma from upside port and aims the plasma axis. Polarization direction, ϑ, measured from toroidal direction can be rotated by a polarizer built in transmission system.

With ϑ of 0 and 180 degrees (electric field oscillates parallel to toroidal direction: O-mode at plasma axis), plasma does not break down. It comes from poor absorption of 2nd harmonic O-mode. Tdelay has its minimum and nl@riseup has its maximum around ϑ of 90 degrees (2nd harmonic X-mode at plasma axis). At the break down phase of plasma by 2nd harmonic ECH, plasma volume is limited around plasma axis so that ϑ of 90 degrees results in X-mode at axis and efficient plasma break down.

On the other hand, nl@100ms has its maximum around ϑ of 120 degrees (2nd harmonic X-mode at plasma edge region). The angle between direction of magnetic field at LCFS and toroidal direction is about 35 degrees. After the expansion and increase of density of plasma, wave's polarization direction basically follows the change of the direction of magnetic field so that X-mode at plasma edge results in X-mode at axis.

With ϑ around 60 and 240 degrees, plasma density decreases during ECH pulses. This is because X-mode component at plasma axis decreases by expansion of plasma. On the contrary, with ϑ around 160 degrees, plasma density increases during ECH pulses because X-mode component at plasma axis increases by expansion of plasma.

Figure 2 shows results of numerical calculation based on equations derived from Fidone and Granata[1]. For the calculation of the ratio of absorbed power, density and temperature profiles for break down phase and heating phase are assumed to expand around magnetic axis and to LCFS, respectively. The calculation explains the experimental results well. At break down phase, maximum absorption is obtained with ϑ of 90 degrees. At heating phase, maximum absorption is obtained with ϑ of 120 degrees.

[1] I. Fidone and G. Granata, Nucl. Fusion **11** (1971) 133

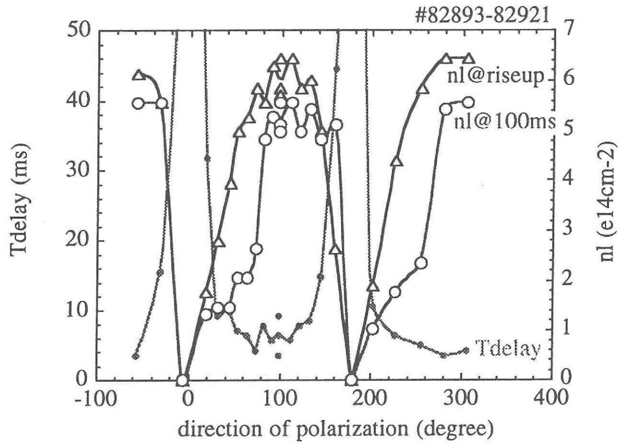

Fig. 1 Measured dependence of Tdelay and nl on ϑ.

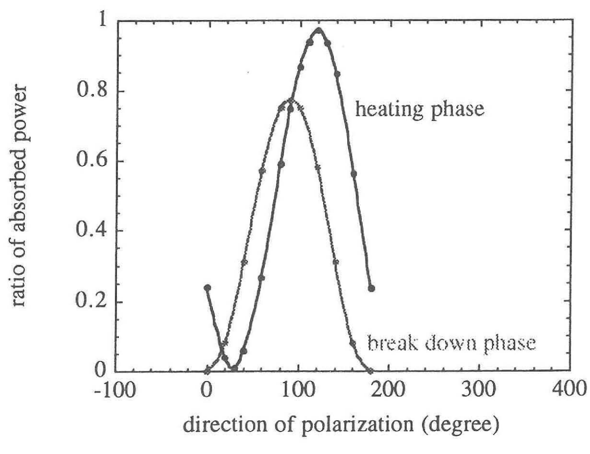

Fig. 2 Calculation of ratio of absorbed power.